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Indian Standard
SPECIFICATION FOR
STEEL FOR VALVES FOR INTERNAL
COMBUSTION ENGINES
(*First Revision*)

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INDIAN STANDARDS INSTITUTION
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

Indian Standard

SPECIFICATION FOR STEEL FOR VALVES FOR INTERNAL COMBUSTION ENGINES

(First Revision)

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Indian Standard
SPECIFICATION FOR
STEEL FOR VALVES FOR INTERNAL
COMBUSTION ENGINES
(First Revision)

0. FOREWORD

0.1 This Indian Standard (First Revision) was adopted by the Indian Standards Institution on 30 December 1981, after the draft finalized by the Alloy Steels and Special Steels Sectional Committee had been approved by the Structural and Metals Division Council.

0.2 This standard was first published in 1974. On the basis of experience gained in the production and use of these steels, the following major modifications have been incorporated in this revision.

a) New grades as given below have been added in Table 1:

1. 40 Ni6 Cr 4 Mo3
2. X85 Cr 18 Mo 2V
3. X20 Cr 21 Ni 12N
4. X70 Cr 21 Mn 6 Ni 2N
5. X55 Cr 21 Mn 8 Ni 2N

b) Table 3 has been modified to include the properties for new grades of steels besides modifications in the existing grades.

0.3 In order to effect variety reduction and to promote economic production of alloy and special steels in the country, IS : 1570-1961* was published as a part of the Steel Economy Programme of the Indian Standards Institution. It has served as the basic standard for specifying steel composition in all the Indian Standards relating to material specifications. In view of the fact that a number of requirements, such as limits for sulphur and phosphorus, method of de-oxidation, and additional tests for specific purposes, have been left to be specified in individual specifications, a need was felt for preparing detailed Indian Standards on the basis of which the material could be indented for. Accordingly it has been decided to formulate these detailed specifications.

*Schedules for wrought steels for general engineering purposes.

0.4 This standard is one of the series of the detailed specifications so formulated. The steels covered by this standard are intended for manufacture of inlet and exhaust valves of internal combustion engines.

0.5 Steel designations in this standard have been aligned with IS : 1762 (Part I)-1974*.

0.6 While formulating this standard, due consideration has been given to ISO/683/XV 'Heat-treated steels, alloy steels and free-cutting steels — Part 15 Valve steels for internal combustion engines' issued by the International Organization for Standardization.

0.7 For the benefit of the purchaser an informative appendix (see Appendix A) giving particulars to be specified by the purchaser while ordering for these steels has been included.

0.8 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS : 2-1960†. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

1. SCOPE

1.1 This standard covers the requirements for wrought unalloyed and alloy steel bars up to and including 40 mm size (diameter in the case of rounds, side of the square in the case of square bars and width across flats in the case of flats) intended for manufacture of valves for internal combustion engines.

2. TERMINOLOGY

2.1 For the purpose of this standard the definitions given in relevant parts of IS : 1956‡ shall apply.

3. SUPPLY OF MATERIAL

3.1 General requirements relating to supply of material shall conform to IS : 1387-1967§.

*Code for designation of steel : Part I based on letter symbols (*first revision*).

†Rules for rounding off numerical values (*revised*).

‡Glossary of terms relating to iron and steels.

§General requirements for the supply of metallurgical materials (*first revision*).

3.2 Steels covered by this standard shall be ordered and delivered on any one of the following basis:

- a) Chemical composition; or
- b) Chemical composition and hardness in the heat-treated or other conditions; or
- c) Chemical composition, hardness and mechanical properties in the heat-treated/or other conditions.

4. MANUFACTURE

4.1 Unless otherwise agreed to in the order, the processes used in making the steel are left to the discretion of the manufacturer. When so desired the purchaser shall be informed of the steel making process.

5. FREEDOM FROM DEFECTS

5.1 The material shall be free from harmful internal and surface defects.

6. CHEMICAL COMPOSITION

6.1 Ladle analysis of steel when undertaken either by the method specified in IS : 228* and its relevant parts or any other established instrumental/chemical method, shall be as given in Table 1.

Method 1.

6.2 Product Analysis — Product analysis shall be carried out on the finished product. Permissible variation in the case of product analysis on the limits specified in Table 1 shall be as given in Table 2.

6.3 Elements not specified in Table 1 shall not be added to the steel, except where agreed to, other than for the purpose of finishing the heat, and shall not exceed the following limits:

<i>Constituent</i>	<i>Percent</i>
Chromium	0.20
Nickel	0.25
Molybdenum	0.10
Copper	0.25
Vanadium	0.05

*Methods of chemical analysis of steels (*second revision*).

TABLE 1 CHEMICAL COMPOSITION PERCENT

(Clauses 6.1, 6.2 and 6.3)

VALVE STEEL No.	STEEL DESIGNATION [see IS : 1762 (Part I)-1974*]	CARBON	SILICON	MANGA- NESE	NICKEL	CHROMI- UM	MOLYB- DENUM	TUNGSTEN	VANADI- UM	SULPHUR max	PHOSPHO- RUS max	NITRO- GEN
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
V-1	55C8	0.50- 0.60	0.10- 0.35	0.60- 0.90	—	—	—	—	—	0.04	0.04	—
V-2	40Cr4	0.35- 0.45	0.10- 0.35	0.60- 0.90	—	0.90- 1.20	—	—	—	0.04	0.04	—
V-3	40Cr4Mo3	0.35- 0.45	0.10- 0.35	0.50- 0.80	—	0.90- 1.20	0.20- 0.35	—	—	0.04	0.04	—
V-4	50Cr4V2	0.45- 0.55	0.10- 0.35	0.50- 0.80	—	0.90- 1.20	—	—	0.15- 0.30	0.04	0.04	—
V-5	25Cr13Mo6	0.20- 0.30	0.10- 0.35	0.40- 0.70	0.30 Max	2.90 3.40	0.45- 0.65	—	—	0.04	0.04	—
V-6	40Ni10Cr3Mo6	0.35- 0.45	0.10- 0.35	0.40- 0.70	2.25- 2.75	0.50- 0.80	0.20- 0.35	—	—	0.04	0.04	—
V-7	40Ni6Cr4Mo3	0.35- 0.45	0.10- 0.35	0.40- 0.70	1.25- 1.75	0.90- 1.30	0.20- 0.35	—	—	0.04	0.04	—
V-8	X45Cr9Si3	0.40- 0.50	2.75- 3.75	0.80 Max	0.50 Max	7.50- 9.50	—	—	—	0.035	0.04	—
V-9	X80Cr20Si2Ni1	0.75- 0.85	1.75- 2.50	0.80 Max	1.00 1.70	19.0- 21.0	—	—	—	0.035	0.04	—

V-10	X85Cr18Mo2V	0.80- 0.90	1.0 <i>Max</i>	1.5 <i>Max</i>	—	16.5- 18.5	2.5 <i>Max</i>	—	0.60 <i>Max</i>	0.035	0.04	—
V-11	X40Ni14Cr14 W3Si2	0.35- 0.50	2.0 <i>Max</i>	1.0 <i>Max</i>	12.0- 15.0	12.0- 15.0	—	2.0- 3.0	—	0.035	0.05	—
V-12	X20Cr21Ni12N	0.15- 0.25	0.75- 1.25	1.5 <i>Max</i>	10.5- 12.5	20.0- 22.0	—	—	—	0.035	0.05	0.15 0.30
V-13	X70Cr21Mn6 Ni2N	0.65- 0.75	0.45- 0.85	5.5- 7.0	1.4- 1.9	20.0- 22.0	—	—	—	0.035+	0.05	0.18- 0.28
V-14	X55Cr21Mn 8Ni2N	0.50- 0.60	1.0 <i>Max</i>	7.0- 9.5	1.5- 2.75	20.0- 22.0	—	—	—	0.035+	0.05	0.20- 0.40
V-15	X53Cr22Mn 9Ni4N	0.48- 0.58	0.25 <i>Max</i>	8.0- 10.0	3.25- 4.50	20.0- 23.0	—	—	—	0.035+	0.05	0.38- 0.55

NOTE — Steels V-1 to V-7 are generally used for inlet valves, and V-8 to V-15 are generally used for exhaust valves.

*Code for designation of steel: Part I Based on letter symbols (*first revision*).

+For free machining properties extra sulphur up to 0.09 may be added.

TABLE 2 PERMISSIBLE VARIATION IN PRODUCT ANALYSIS

CONSTITUENT	(Clause 6.2)	
	PERCENT	PERMISSIBLE VARIATION, PERCENT
Carbon	Up to 0.60	± 0.02
	>0.60 to ≤ 0.90	± 0.03
Silicon	Up to 1.0	± 0.05
	>1.0 to ≤ 2.0	± 0.10
	>2.0	± 0.15
Manganese	Up to 1.5	± 0.04
	>1.5	± 0.06
Nickel	Up to 0.5	± 0.03
	>0.5 to ≤ 4.5	± 0.07
	>4.5 to ≤ 15.0	± 0.15
Chromium	Up to 0.90	± 0.03
	>0.90 to ≤ 3.5	± 0.05
	>3.5 to ≤ 9.5	± 0.10
	>9.5 to ≤ 15.0	± 0.20
	>15.0	± 0.25
Molybdenum	Up to 0.65	± 0.03
	>0.65	± 0.05
Tungsten	2.0 to 3.0	± 0.10
Vanadium	Up to 0.60	± 0.03
Sulphur	Up to 0.09	$+0.005$
Phosphorus	Up to 0.05	$+0.005$
Nitrogen	Up to 0.20	± 0.01
	>0.20 to ≤ 0.30	± 0.02
	>0.30 to ≤ 0.55	± 0.03

7. CONDITION OF DELIVERY

7.1 Steel shall be supplied in any condition of heat treatment or surface machining as agreed between the purchaser and the manufacturer.

7.2 Recommended heat treatments for these steels are given in Appendix B.

8. HARDNESS

8.1 The hardness for steels delivered in heat treated condition when determined in accordance with IS : 1500-1968* shall be as given in Table 3.

*Method for Brinell hardness test for steel (first revision).

TABLE 3 TYPICAL HARDNESS AT ROOM TEMPERATURE IN THE FINALLY HEAT TREATED CONDITION

(Clause 8.1)

VALVE STEEL No.	CONDITION OF HEAT TREATMENT*	BRINELL HARDNESS HB
V - 1	Q+T	255-293
V - 2	Q+T	255-293
V - 3	Q+T	255-293
V - 4	Q+T	255-293
V - 5	Q+T	255-293
V - 6	Q+T	255-293
V - 7	Q+T	255-293
V - 8	Q+T	255-293
V - 9	Q+T	255-306
V - 10	Q+T	255-306
V - 11	ST	302 <i>Max</i>
V - 12	ST	302 <i>Max</i>
V - 13	ST+P	321 <i>Min</i>
V - 14	ST+P	321 <i>Min</i>
V - 15	ST+P	321 <i>Min</i>
V - 15	SR	390 <i>Max</i> †

*Q=Quenched; T=Tempered; ST=Solution treated; P=Precipitation hardened; SR=Stress relieved.

†This value does not take into account the effect of work hardening which can result in a higher hardness.

8.1.1 The hardness in any other conditions other than the given in Table 3 shall be as agreed to between the purchaser and the manufacturer. However, the typical values for hardness in the hot rolled as well as in the hot rolled and annealed conditions are given in Table 4 for information only.

9. MECHANICAL PROPERTIES

9.1 Typical mechanical properties at room temperature for heat treated condition given in Appendix B are given in Table 5 for information only.

9.1.1 The properties given in Table 5 and in Appendix C are applicable to test pieces taken on rounds in the direction of the fibre, the axis of which corresponds to Fig. 1. For rectangular sections the ranges for equivalent sections shall be as given in Fig. 2.

9.1.2 If required by the purchaser, steels when supplied in conditions other than the heat-treated condition as specified in Table 5, shall have the mechanical properties as agreed to between the purchaser and the manufacturer.

TABLE 4 TYPICAL HARDNESS VALUES AT ROOM TEMPERATURE IN THE HOT ROLLED OR HOT ROLLED AND ANNEALED CONDITION
[FOR INFORMATION ONLY]

(Clause 8.1.1)

VALVE STEEL No.	CONDITION OF HEAT TREATMENT	BRINELL HARDNESS HB Max
V - 1	annealed	220
V - 2	do	220
V - 3	do	220
V - 4	do	220
V - 5	do	230
V - 6	do	250
V - 7	do	230
V - 8	do	320
V - 9	do	330
V - 10	do	330
V - 11	hot rolled	302
V - 12	do	302
V - 13	do	390
V - 14	do	390
V - 15	do	390

TABLE 5 TYPICAL MECHANICAL PROPERTIES AT ROOM TEMPERATURE IN THE FINALLY HEAT TREATED CONDITION
[FOR INFORMATION ONLY]

(Clauses 9.1, 9.1.1 and 9.1.2)

VALVE STEEL No.	CONDITION OF HEAT TREATMENT*	TENSILE STRENGTH N/mm ² †	YIELD STRENGTH N/mm ²	ELONGATION ON GAUGE LENGTH 5.65√A, PERCENT	REDUCTION IN AREA, PERCENT,
		Min	Min	Min	Min
(1)	(2)	(3)	(4)	(5)	(6)
V-1	Q+T	790	530	—	—
V-2	Q+T	790	590	—	—
V-3	Q+T	890	690	—	—
V-4	Q+T	890	690	—	—
V-5	Q+T	890	690	—	—
V-6	Q+T	890	690	—	—
V-7	Q+T	890	690	—	—
V-8	Q+T	930	685	16	40
V-9	Q+T	930	735	10	15
V-10	Q+T	1080	835	12	15
V-11	ST	785	345	35	40
V-12	ST	835	440	25	25
V-13	ST+P	1030	540	20	30
V-14	ST+P	1030	490	20	30
V-15	ST+P	1030	640	8	10
V-15	SR	1080	830	20	10

*Q=Quenched; T=Tempered; ST=Solution treated; P=Precipitation hardened;
SR=Stress relieved.

†1 Kg/mm²=9.81 N/mm².

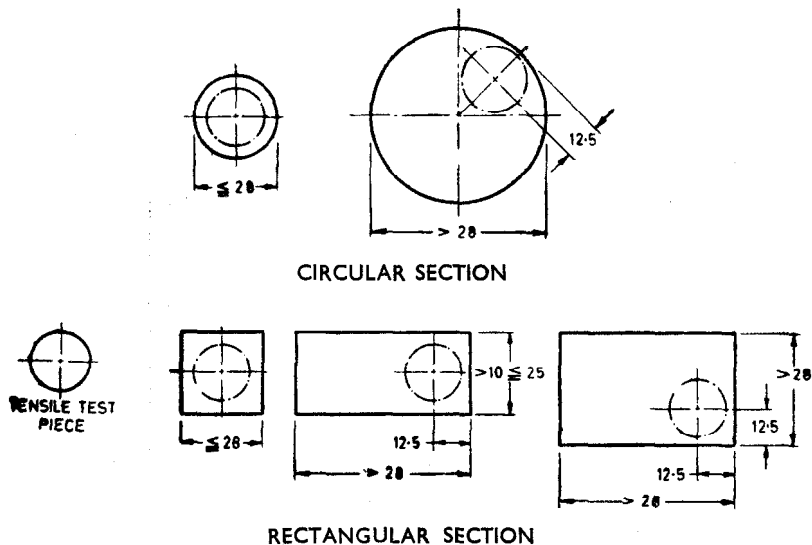


FIG. 1 LOCATION OF TENSILE TEST PIECES

9.2 Tensile test shall be carried out in accordance with IS : 1608-1972*.

10. INCLUSION RATING

10.1 Inclusion rating of the steel shall be determined in accordance with IS : 4163-1967†. The worst field of each inclusion from each specimen shall be recorded as a rating for the specimen.

10.1.1 The inclusion rating of the specimens shall not exceed the following limits:

<i>Oxide</i>	<i>Slag</i>
3	3

NOTE — The average values of inclusion in such steels are, normally, within half the values specified above.

11. ELEVATED TEMPERATURE PROPERTIES

11.1 For the guidance of the users, elevated temperature properties for the exhaust valve steels, from valve steel No. V-8 to V-15, in the heat treated condition are given in Appendix C.

*Method for tensile testing of steel products (*first revision*).

†Method for determination of inclusion content in steel by microscopic method.

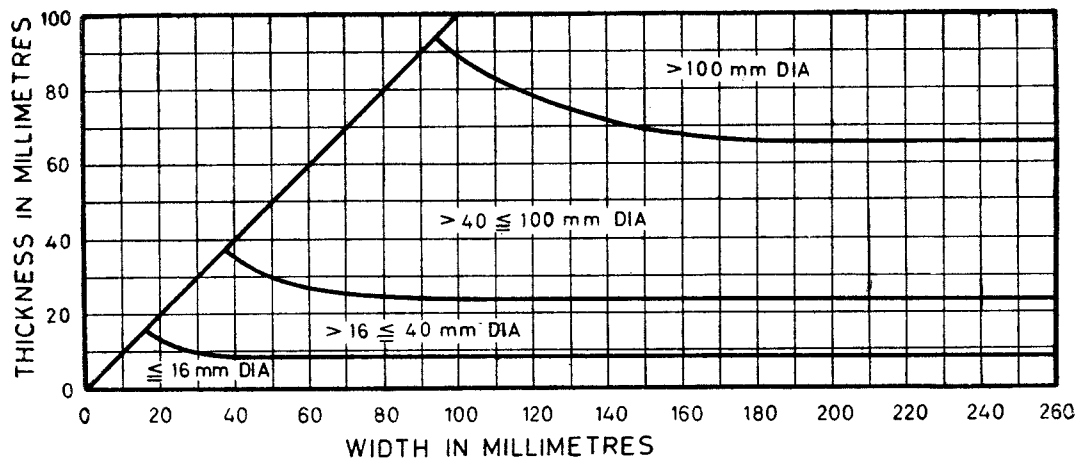


FIG. 2 APPLICABILITY OF THE VALUES, GIVEN IN TABLE 5 FOR ROUND SECTION, TO RECTANGULAR SECTION OF OIL OR WATER-QUENCHED PRODUCTS

12. DIMENSIONAL TOLERANCES

12.1 The dimensional tolerances for steel bars shall be in accordance with IS : 3739-1972*.

12.2 For forged bars, the tolerances shall be as specified in 'Indian Standard' specification for machining allowances and tolerances for open die steel forging: Part II High alloy steel forgings (*under preparation*).

12.3 For bars in the drawn and centreless ground conditions, the tolerances shall be as agreed to between the purchaser and the manufacturer.

13. SAMPLING

13.1 Sampling for Chemical Analysis — The ladle analysis shall be supplied by the producer. If a product analysis is required by the purchaser, at least one sample product shall be taken from each cast.

13.2 Sampling for Hardness in the Heat Treated Condition — One sample product shall be taken from each heat-treated batch subject to the minimum of at least one sample from each cast for the determination of hardness.

13.3 Sampling for Mechanical Properties — If required by the purchaser, one sample product shall be taken from each size grouping of each heat-treated batch for testing. If the product is continuously heat-treated, the sampling for mechanical tests shall be as agreed to between the purchaser and the manufacturer.

13.4 Sampling for hardness and mechanical properties in conditions other than heat-treated condition, shall be as agreed to between the purchaser and the manufacturer.

13.5 General conditions for selection and preparation of samples and test pieces shall be in accordance with IS : 3711-1966†.

14. RETESTS

14.1 Retest for Product Analysis — If the results of the product analysis do not meet the composition requirements given in Tables 1 and 2, unless otherwise agreed to between the purchaser and the manufacturer two new samples shall be taken on different pieces from the same cast. Should the two analysis satisfy the requirements, the lot represented shall be accepted. Should either of the tests fail, the material shall be taken as not complying with this standard.

*Dimensional tolerances for carbon and alloy constructional steel products.

†Method for selection and preparation of samples and test pieces for mechanical tests for wrought steels.

14.2 Retest for Hardness and Mechanical Tests in the Heat Treated Condition — If the samples selected under **13.2**, **13.3** and **13.4** fail to meet the requirements stipulated two further samples shall be selected from the same heat treated batch or lot. The consignment shall be considered to conform to the requirements if both the additional tests are satisfactory. Should either of the samples fail, the manufacturer shall have the right, if he so desires in case of heat-treated material to reheat-treat the product in any suitable manner before two fresh samples are taken for testing. Should the two tests satisfy the requirements of this standard, the lot represented shall be accepted. Should either of the samples fail, the material shall be taken as not complying with this standard.

15. PACKING AND MARKING

15.1 Steel bars shall be suitably bundled. A metal tag giving the following information shall be attached to each bundle:

- a) Name and trade-mark of the manufacturer,
- b) Steel grade, and
- c) The cast number or any other identification mark by which the steel can be traced to the cast and heat treatment batch from which it was made.

15.1.1 The colour scheme specified in IS : 2049-1978* or as required by the purchaser may be adopted to mark the grade of the material.

15.2 The material may also be marked with the ISI Certification Mark.

NOTE — The use of the ISI certification Mark is governed by the provisions of the Indian Standards Institution (Certification Marks) Act and the Rules and Regulations made thereunder. The ISI mark on products covered by an Indian Standard conveys the assurance that they have been produced to comply with the requirements of that standard under a well-defined system of inspection, testing and quality control which is devised and supervised by ISI and operated by the producer. ISI marked products are also continuously checked by ISI for conformity to that standard as a further safeguard. Details of conditions under which a licence for the use of the ISI Certification Mark may be granted to manufacturers or processors, may be obtained from the Indian Standards Institution.

*Colour code for the identification of wrought steels for general engineering purposes (first revision).

APPENDIX A

(*Clause 0.7*)

BASIS FOR ORDER

A-1. While placing an order for the steels covered by this standard, the purchaser should specify clearly the following:

- a) Grade;
- b) Condition of supply;
- c) Size;
- d) Test requirements;
- e) Special requirements, such as bundling and packing;
- f) Method of manufacture; and
- g) Test report, if required.

APPENDIX B

(Clause 7.2)

RECOMMENDED HEAT TREATMENT OF VALVE STEELS

VALVE STEEL No.	STEEL DESIGNATION	SYMBOL	NORMALIZING TEMPERATURE °C	SYMBOL	HARDENING SOLUTIONIZING TEMPERATURE °C	QUENCHING MEDIUM	TEMPERING TEMPERATURE °C
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
V-1	55C8	N	810—840	Q+T	810—840	Oil	550—660
V-2	40Cr4	N	860—890	Q+T	860—890	Oil	550—700
V-3	40Cr4Mo3	N	860—890	Q+T	860—890	Oil	550—700
V-4	50Cr4V2	—	—	Q+T	850—880	Oil	400—650
V-5	25Cr13Mo6	—	—	Q+T	880—910	Oil	550—750*
V-6	40Ni10Cr3Mo6	—	—	Q+T	820—850	Oil	500—660
V-7	40Ni6Cr4Mo3	—	—	Q+T	820—850	Oil	500—660
V-8	X45Cr9Si3	—	—	Q+T	1 020—1 070	Oil or air	720—820
V-9	X80Cr20Si2Ni1	—	—	Q+T	1 050—1 080	Oil or air	700—800
V-10	X85 Cr 18 Mo 2 V	—	—	Q+T	1 050—1 080	Oil	700—750
V-11	X40Ni14Cr14 W3Si2	—	—	ST	980—1 080	Water, oil or air	—
V-12	X20Cr21Ni 12 N	—	—	ST+ (P)	1 100—1 200	Oil or water	700—800
V-13	X70 Cr 21 Mn 6 Ni 2 N	—	—	ST+ P	1 100—1 200	Water	730—780†
V-14	X55 Cr 21 Mn 8 Ni 2 N	—	—	ST+ P	1 100—1 200	Water	730—780†
V-15	X53 Cr 22 Mn 9 Ni 4 N	—	—	ST+ P	1 100—1 200	Water	730—800†

N=Normalizing; Q=Quenching; T=Tempering; ST=Solution Treatment; P=Precipitation

*Stabilization temperature 550°C.

†Temperature for ageing treatment.

APPENDIX C

(Clauses 9.1.1 and 11.1)

TYPICAL TENSILE PROPERTIES AT ELEVATED TEMPERATURES

VALVE STEEL No.	STEEL DESIGNATION	CONDITION OF HEAT TREATMENT*	TENSILE STRENGTH, N/mm ² , Min, at							
			500°C	550°C	600°C	650°C	700°C	750°C	800°C	850°C
V-8	X45Cr9Si 3	Q+T	490	365	245	155	110	70	—	—
V-9	X80 Cr 20 Si 2 Ni 1	Q+T	590	460	345	245	145	110	70	—
V-10	X85Cr18Mo2V	Q+T	540	410	295	235	175	135	100	—
V-11	X40Ni14Cr14W 3Si 2	ST	540	510	490	390	315	225	195	—
V-12	X20Cr21Ni12N	ST+(P)	590	550	510	450	390	345	295	—
V-13	X70Cr21Mn6Ni2N	ST+P	640	590	540	490	440	365	295	—
V-14	X55Cr21Mn8Ni2N	ST+P	640	600	560	500	440	365	295	—
V-15	X53Cr22Mn 9Ni 4 N	ST+P	640	600	560	500	440	365	325	245

*Q=Quenched; ST=Solution treated; T=Tempered; P=Precipitation hardened

(Continued from page 2)

Subcommittee for Stainless, Heat Resisting and Valve Steels, SMDC 19:7

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INTERNATIONAL SYSTEM OF UNITS (SI UNITS)

Base Units

Quantity	Unit	Symbol
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	kelvin	K
Luminous intensity	candela	cd
Amount of substance	mole	mol

Supplementary Units

Quantity	Unit	Symbol
Plane angle	radian	rad
Solid angle	steradian	sr

Derived Units

Quantity	Unit	Symbol	Definition
Force	newton	N	1 N = 1 kg.m/s ²
Energy	joule	J	1 J = 1 N.m
Power	watt	W	1 W = 1 J/s
Flux	weber	Wb	1 Wb = 1 V.s
Flux density	tesla	T	1 T = 1 Wb/m ²
Frequency	hertz	Hz	1 Hz = 1 c/s (s ⁻¹)
Electric conductance	siemens	S	1 S = 1 A/V
Electromotive force	volt	V	1 V = 1 W/A
Pressure, stress	pascal	Pa	1 Pa = 1 N/m ²

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